

SOIL TEST BASED FERTILIZER RECOMMENDATIONS FOR TARGETED YIELDS OF RABI MAIZE (*ZEAMAYS*) IN VERTISOLS OF TELANGANA STATE

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ABSTRACT

Investigations were carried out on Response of Maize (*Zea mays* L.) grain yield (kg/ha) and ratio (kg/kg) to the nutrients applications in Telangana state (Soil Test Crop Response Correlation) during 2008 and 2009 at Regional Agricultural Research Station, Warangal. The experiment were conducted at different sites adjacent to each other on a sandy clay loam soil having a low status in available nitrogen (272kg/ha) in the first year and medium (323kg N/ha) in the second year. The soil available phosphorus had a medium status with 60 kg P₂O₅/ha in the first year and 50. kg P₂O₅/ha in the second year. It was rich in available potassium having 719 and 829 kg K₂O/ha during the corresponding years. The correlation coefficients between grain yield and nutrients were significant with N P K uptake, their supply through fertilizers and soil N and K but not P in the two years. The basic data to produce one quintal of grain was estimated at 1.86 kg N; 1.23 kg P and 0.50 kg K in the first year while it was 2.10 kg N, 1.03 kg P and 0.54 kg K in the second year. The soil and fertilizer efficiency was almost equal to contribute nitrogen while the soil was more efficient to supply P than the fertilizer and the efficiency of the soil to supply K was less than the fertilizer during two year. The targeted yield equations developed from these basic data were

2008	2009
$FN = 6.60T - 0.95 SN$	$FN = 9.40 T - 1.32 SN$
$FP = 5.54 T - 16.07 SP$	$FP = 2.81 T - 8.93 SP$
$FK = 2.99T - 0.12 SK$	$FK = 3.37 T - 0.18SK$

The ready reckoner for targeted yield of 40, 50 and 60 q/ha maize grain yield exhibited considerable variation in the prescription of fertilizers for given soil available nutrients. Hence composite targeted yield equation was developed as mean of two years as per the Project Directorate on All India Coordinated Research projection for Soil Test Crop Response Correlation as.

$$FN = 7.27 T - 1.09 SN$$

$$FP = 3.84 T - 11.63 SP$$

$$FK = 3.17 T - 0.15 SK$$

The ready recokoner for a range of soil test available NPK are furnished. These are to be verified in the farmer's fields on sandy loam soils of Central Telangana Zone for recommendations.

KEYWORDS: Soil Test Approach, Targeted Yield Approach & Recommendation of Fertilizer in Rabi Maize Crop

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INTRODUCTION

The fertilizer requirement of different crops varies due to their differential production potential, ability to draw the mineralized soil nutrients and their additions through the fertilizers. Soil testing is a pre-requisite to know the nutrient imbalance in the soils so as to apply the required amounts of nutrients to correct the imbalance, optimize the crop nutrition for high yield, fetch lucrative profits and maintain the soil health. Therefore fertilizer recommendations for different crops are most often made on the basis of initial soil nutrient status by categorizing them into low, medium and high fertility classes. Such considerations hold good for large variation in soil fertility from field to field. To overcome this limitation, the concept of prescription based fertilizer recommendation for a given soil, crop and environment was proposed through the targeted yield equations developed by Truog (1960). Among the various methods of fertilizer recommendations, the one based on yield targeting is unique because this method not only considers the soil test based fertilizer dose but also the level of yield the farmer can achieve if good agronomic practices are followed to raise the crop. This targeted yield approach is also scientifically sound as the balanced fertilization is ensured not only among the fertilizer nutrients but also the soil available nutrients. Rao and Srivastava (1999) reiterated that the soil test calibration is intended to establish a relationship between the levels of soil nutrients as determined in the laboratory and the crop response to fertilizers observed in the field, permits balanced fertilization of crops. The great complexity in soil test crop response accrues due to a great variety of soils, different climates, crops and management practices. Therefore a well established soil test calibration helps to apply fertilizers in precise amounts and obtain high use efficiency for maximum possible yield in an eco-system. The targeted yield approach based on the soil test crop correlation studies refined by Ramamoorthy *et al.* (1967) for the first time in India has been successfully adopted through the results obtained from the national net work of All India Coordinated Research Project on Soil Test Crop Response Correlation studies. The basic data needed for formulating fertilizer recommendation based on targeted yield approach are nutrient requirement in kg/q produce (grain or other economic produce); the percentage contribution from soil available nutrients and percentage contribution from the fertilizer nutrients.

Targeted yield equations were developed for a number of crops in different parts of Andhra Pradesh (Reddy *et al.*, 1999; Reddy and Ahmed, 2000; Khadke and Ahmed, 2000; Meena *et al.*, 2001; Sreedevi *et al.*, 2001; Chhetri Binoy, 2006 and Swetha, 2006). But, fertilizer recommendations based on this approach for maize in the Central Telangana Zone have not yet been investigated. Maize is a nutrient exhaust crop. It depletes the soil fertility fast. Sridhar *et al.* (1991) reported that an adequately irrigated crop of maize in the winter season removed 92.9 kg N, 35.7 kg P and 110 kg/ha. This huge depletion should be replenished through external inputs to sustain the fertility level. Available literature shows that maize respond to heavy dressing of fertilizers up to 180:90:60 kg/ha N P K (Sutaliya and Singh 2005). In another investigation, Kumar *et al.* (2005) recorded significant improvement in yield by increasing the recommended dose of 120:60:40 kg/ha N P K to the extent of 150%. This result signifies that there is a need to revise the fertilizer schedule from time to time. Farmers in Telangana state seldom follow the recommended dose of 120:60:50 kg/ha. The fertilizer application is indiscriminate.

MATERIALS AND METHODS

The experiment was conducted at the Regional Agricultural Research Station, Warangal, Telangana State to study Response of Maize (*Zea mays* L.) grain yield(kg/ha) and ratio (kg/kg) to the nutrients applications (Soil Test Crop Response Correlation) during *Rabi* 2008 and 2009. The experimental site is geographically located at 18°03' N latitude and

79°22' E longitude at an altitude of 270 m above the mean sea level. The experiments were conducted at two different sites in the two years adjacent to each other by about 15 m. Composite soil sample was drawn from 0 to 30 cm depth from different spots moving randomly in a zig zag manner, in the entire field before the commencement of the experiment. It was analyzed for different physico-chemical properties by adopting standard procedures. The soil was sandy clay loam in texture. It had an alkaline reaction having a pH of 8.10 during 2007 and 8.37 during 2008. There was no problem of salt accumulation in either of the two years. There was a low organic carbon content of 0.47 per cent in the first year and 0.40 per cent in the second year. The fertility status in terms of available nitrogen was different. In the first year, it had a low status with 272.34 kg N / ha while it was medium with 323.67 kg N / ha in the subsequent year. The status of phosphorus was medium with 60 P₂O₅/ ha in the first year and 50 kg P₂O₅/ha in the second year. It was very rich in potassium. The available quantity of K₂O was 719 kg / ha in the first year and 829 kg / ha in the second year. The main aim of the Soil Test Crop Response experiment was to generate a set of data points with a wide range of values for each controllable variable of fertilizer NPK at different levels of the uncontrollable soil available NPK fertility variables. To achieve this objective, a fertility gradient experiment was conducted. This was to ensure high heterogeneity between the different fertility gradients and homogeneity within each soil fertility gradient for available soil nutrients, management practices adopted and prevailing climatic conditions. The field was divided into three strips. Each strip was 90 m long and 16 m wide separated with 1.5 m wide alley way all along the length. These strips were designated as O X, 1 X and 2 X depending upon the quantity of fertilizers added. Fertilizers were not added in the O X gradient. The standard level of 150 kg N/ha was applied in 1 X strip. Phosphorus application was calibrated to the critical value based on its fixation capacity following Waugh and Fitts (1966). To supply 10 ppm P, a dose of 22.4 kg P₂O₅ /ha was applied to 1 X strip. The potassium application was calibrated to supply 150 kg exchangeable K₂O/ha. Since soil available K status of the soil was high, a minimum dose of 30 kg K₂O / ha was applied. The 2 X strip was fertilized with two times the standard dose of nutrients in 1 X gradient. These fertilizer levels are those recommended by the All India Coordinated Research Project on Soil Test Crop Response Correlation Studies.

The exhaust crop of fodder sorghum variety SSG 59-3 was sown during *kharif* on 1st July, 2007 and 22nd June, 2008. The crop was harvested at flowering stage both years. The fodder yield was recorded from each strip. After the harvest of exhaust crop, the field was ploughed, harrowed and leveled without disturbing the layout demarcation of the three strips developed for the fertility gradient experiment. Each strip was divided into 24 plots measuring 7.0 x 7.8 m. These plots were separated by bunds measuring 45 cm and alternated by feeder channels of 75 cm for irrigation

The Treatments were a Combination of Four Levels of Each N, P and K viz.,

Nitrogen (kg N/ha)	Phosphorus (kg P ₂ O ₅ /ha)	Potassium (kg K ₂ O/ha)
N ₀ -0	P ₀ -0	K ₀ -0
N ₁ -80	P ₁ -40	K ₁ -40
N ₂ -160	P ₂ -80	K ₂ -80
N ₃ -240	P ₃ -120	K ₃ -120

A set of 21 treatments comprising the combined levels of NPK and 3 unfertilized controls were randomly allocated in each fertility gradient strip for soil test crop response experiment in accordance with the recommendation by the All India Coordinated Research Project on soil test crop response correlation studies (www.iasir.res.in). The fertilizers

were applied to the plots as per the treatments. One third of nitrogen and full dose of phosphorus and potassium were applied as a basal dose and remaining nitrogen was applied as top dressing at 40 days after sowing and tasseling stage. The crop was irrigated at the time of sowing and remaining six irrigations were given at 25, 40, 55, 70, 85 and 95 days after sowing

The three basic parameters required to calculate the targeted yield were worked out by following the procedure laid out by Ramamoorthy *et al.* (1967) as follows.

Nutrient Requirement of N, P and K for Grain Production

$$\text{Kg nutrient /q of grain} = \frac{\text{Total uptake of nutrient (kg) (Grain + Straw)}}{\text{Grain yield (q)}}$$

Percent Contribution of Nutrient from Soil (CS)

$$\% \text{ Contribution from soil (CS)} = \frac{\text{Total uptake in control plots (kg/ha)} \times 100}{\text{Soil test values of nutrient in control plots (kg/ha)}}$$

Per cent Contribution of Nutrient from Fertilizers (CF)

$$\% \text{ Contribution of } \left[\begin{array}{c} \text{Nutrient} \\ \text{uptake} \\ \text{kg /ha} \end{array} \right] = \frac{\left[\begin{array}{cc} \text{Available} & \% \text{ contribution} \\ \text{soil} & \text{x of nutrients} \\ \text{test value} & \text{from soil/100} \end{array} \right] \text{ kg /ha}}{\text{fertilizer nutrient applied kg/ha}} \times 100$$

Targeted Yield Equation: It was worked out as follows

$$T = \left[\begin{array}{c} \text{Nutrient requirement} \\ \text{-----} \times T \\ \text{\% contribution from} \\ \text{fertilizer} \end{array} \right] - \left[\begin{array}{cc} \% \text{contribution from soil} & \text{Soil test} \\ \text{-----} & \text{value for} \\ \% \text{contribution from fertilizer} & \text{available} \\ & \text{nutrient} \end{array} \right]$$

Calculation of Fertilizer Dose

The basic data are transformed into workable adjustment equation as follows:

$$\text{Fertilizer dose} = \frac{\text{Nutrient required in kg/q of grain}}{\% \text{ CF}} \times 100 \times T \times \frac{\% \text{ CS}}{\% \text{ CF}} \times \text{Soil test value}$$

= a constant x yield target (q/ha) - b constant x soil test value (kg/ha)

RESULTS AND DISCUSSIONS

Basic Data for Targeted Yield Equations

The basic data on nutrient requirement to produce per kg of grain and the contribution of N P K through the soil and fertilizers is presented in Table 1. The crop required 1.86 kg N, 1.23 kg P and 0.50 kg K/ha to produce 1 quintal of maize grain during the first year. The requirement of these nutrients was 2.10, 1.03 and 0.54 kg respectively during the second year. The efficiency of soil was estimated to be 26.04 percent for the available nitrogen in the first year and 33.08 per cent in the second year. The contribution of N through the fertilizer was 19.78 per cent in the first year and 34.68 per cent in second year. The efficiency of the soil supplying P for the formation of grain was 155.83 per cent in the first year and 143.09 per cent in the second year. The fertilizer contributed 22.20 and 36.68 per cent P during the two years. The efficiency of the soil to supply potassium was very low. It contributed only 1.70 and 2.46 per cent of its available content during the two years. The relative efficiency of fertilizer supplying this nutrient was relatively less than P or N during the two years. Its contribution was 16.73 per cent K₂O in first year and 16.03 per cent in the second year. The response ratio of the three nutrients viz; N P K to produce per kg grain was 5.58 in the first year and 8.18 in the second year.

The mean values over the second year showed that maize required 1.98 kg nitrogen 1.13 kg phosphorus and 0.52 kg potassium to produce one quintal of grain. The efficiency of nitrogen supplied by the soil and fertilizer was almost equal. The soil supplied 29.56 per cent of the available nitrogen while the contribution of fertilizer was 27.23 per cent. The response to soil nitrogen and fertilizer phosphorus was highly variable. The soil supplied 149.46 per cent P while the fertilizer was efficient to contribute 29.44 per cent of this nutrient. The soil was relatively less efficient to supply 2.08 per cent potassium unlike the contribution 16.38 per cent by the fertilizer. The mean response ratio was 7.0 kg grain/kg nutrient applied.

Targeted Yield Equation

The targeted yield equations obtained from basic data were as follows:

2008	2009
FN = 9.40 T – 1.32 SN	FN = 6.60 T – 0.95 SN
FP = 5.54 T – 16.07 SP	FP = 2.81 T – 8.93 SP
FK = 2.99 T – 0.12 SK	FK = 3.37 T – 0.18 SK
Mean	
FN = 7.27 – 1.09 SN	
FP = 3.84 – 11.63 SP	
FK = 3.17 – 0.15 SK	

Ready Reckoner for Soil Test based Fertilizer Recommendations

The ready reckoner for fertilizer application to attain desired yield level of 40, 50 and 60 q/ha grain yield of maize for different soil nutrient test values ranging from 125 to 200 kg N, phosphors from 8 to 20 and potassium from 500 to 530

kg/ha is furnished in table 2. The level of nitrogen to be applied for different soil test levels within the range of 200 to 340 kg N, phosphorous from 4 to 16 kg and potassium from 560 to 640 kg/ha estimated from the fertility gradients of the second year are furnished in table 3. A mean estimate over the two years is presented in table 4 to prescribe the quantity of nitrogen, phosphorous and potassium to be applied for targeted yield of 40, 50 and 60 q/ha over a range of soil test values for the Central Telangana Zone

The concept of fertilizer prescription for desired crop yield based on the soil available nutrients was enunciated by Truog (1960) and later tested in India by Ramamoorthy *et al*, (1967) based on the premise that the relationship between grain yield and uptake of nutrient follow a linear relationship. The fertilizer requirement can be estimated through the basic data. In the present investigation, the basic data showed that the nutrient requirement of maize was 1.86 and 2.10 kg N, 1.23 and 1.03 kg P and 0.50 kg K per quintal of grain during 2008 and 2009. The efficiency of the soil to supply the nutrients was 26.03 and 33.08% N, 155.83 and 143.09 % P and 1.70 and 2.46 % K during the respective years. The fertilizer was less efficient and supplied 19.78% N compared to 26.04% by the soil in the first year. But it was equally efficient to contribute 34.68% N as that of 33.08% through the soil. The fertilizer was less efficient to supply P than the soil while the reverse was true for potassium.

The results of previous experiments conducted by several investigators indicate that the nutrient requirement needed to produce one quintal of grain varied considerably even for the same crop. The literature showed that the fertilizers were more efficient to supply N and K than those available in the soil for grain yield. But the efficiency of soil and fertilizer was highly inconsistent.

Based on the basic data, adjustment equations were generated to predict the nutrient requirement for the targeted yield of 40, 50 and 60 q/ha maize grain for different soil test ranges created within the experiment during each year. The ready reckoner to prescribe the optimum level of fertilizers depending on the level of nutrients available in the soils was not consistent during the two years. Hence, composite adjustment equation pooling the basis data over the two years was attempted and a ready reckoner for fertilizer prescriptions to target 40, 50 or 60 q/ha maize grain in the sandy clay loam soils of Central Telangana Zone is furnished. In their exhaustive and critical review Rao and Srivasthava (1999) reported that the adjustment equation for a particular crop or varieties of a crop varied in different seasons or years due to changes in weather. So the soil test calibrations derived from the equations also tended to vary from one year to another. They suggested that possible approach to overcome this problem is to generate a composite adjustment equation by pooling the basic data over the years. The fertilizer recommendations derived from such an approach may be more appropriate and less subjected to year to year fluctuations due to seasonal or weather related changes.

The results on evaluation of fertilizer responses highlighted the usefulness to apply liberal dose of nutrients up to 240 kg N, 120 kg P₂O₅ and 120 kg K₂O/ha to realize high grain and fodder yield of maize and profits. The targeted yield equations were more useful to provide a ready reckoner for fertilizer application rates that are conservative and balanced for desired yield goals of 40, 50 or 60 q/ha to suit the highly variable soil available nutrients that vary from field to field and the capacity of the farmer to invest money. The prescription of fertilizer application rates can be extended to the soil available nutrients indicated in the ready reckoner without extrapolation in the sandy clay loam soils of Central Telangana Zone in Telangana state.

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APPENDICES

Table 1: Basic Data on Nutrient Requirement, Soil and Fertilizer Efficiency of Maize

Nutrient	Rabi 2007-08			Rabi 2008-09			Mean		
	NR (kg/q)	SE (%)	FE (%)	NR (kg/q)	SE (%)	FE (%)	NR (kg/q)	SE (%)	FE (%)
N	1.86	26.04	19.78	2.10	33.08	34.68	1.98	29.56	27.23
P	1.23	155.83	22.20	1.03	143.09	36.68	1.13	149.46	29.44
K	0.50	1.70	16.73	0.54	2.46	16.03	0.52	2.08	16.38
Response ratio (kg/kg)	5.58			8.18			7.00		

Table 2: Ready Reckoner of Soil Test Based Fertilizer Doses for Attaining Different Yield Targets of Maize during 2007-08

Soil Nutrients (kg/ha)			Fertilizer N, P and K Doses (kg/ha) for Different Yield Targets								
			T = 40 q/ha			T = 50 q/ha			T = 60 q/ha		
SN	SP	SK	FN	FP	FK	FN	FP	FK	FN	FP	FK
125	8	500	210	93	60	305	148	90	399	204	119
130	10	505	204	61	59	298	116	89	392	172	118
140	12	510	191	29	58	285	84	88	379	140	118
150	14	515	178	0	58	272	52	88	366	107	118
160	16	520	165		57	259	20	87	353	75	117
170	18	525	152		57	246	0	87	340	43	116
180	20	530	138		56	232		86	326	11	226
190			125			219			313		
200			112			206			300		

Table 3: Ready Reckoner of Soil Test Based Fertilizer Doses for Attaining Different Yield Targets of Maize during 2008-09

Soil Nutrients (kg/ha)			Fertilizer n, p and k Doses (kg/ha) for Different Yield Targets								
			T = 40 q/ha			T = 50 q/ha			T = 60 q/ha		
SN	SP	SK	FN	FP	FK	FN	FP	FK	FN	FP	FK
200	4	560	52	77	34	113	105	68	174	133	101
220	6	580	33	59	30	94	87	64	155	115	97
240	8	600	15	50	27	75	69	60	136	97	94
260	10	620	0	23	23	56	51	57	117	79	91
280	12	640		5	20	37	33	53	98	61	87
300	14					18	15		79	44	
320	16					0	0		60		
340									41		

Table 4: Ready Reckoner of Soil Test Based Fertilizer Doses for Attaining Different Yield Targets of Maize Pooled Data during 2007 and 2008

Soil Nutrients (kg/ha)			Fertilizer N, P and K Doses (kg/ha) for Different Yield Targets								
			T = 40 q/ha			T = 50 q/ha			T = 60 q/ha		
SN	SP	SK	FN	FP	FK	FN	FP	FK	FN	FP	FK
130	4	500	149	107	52	222	145	84	294	184	115
150	6	520	127	84	49	200	122	81	272	160	112
170	8	540	106	61	46	179	99	78	251	138	109
190	10	560	84	38	43	157	76	75	229	114	106
210	12	580	62	15	40	135	53	72	207	91	103
230	14	600	0	0	37	113	30	69	185	68	100
250	16	620			34	92	6	66	164	44	97
270	18	640			31	70	0	63	142	21	94
290	20					48			120	0	
310						26			98		
330						4			76		